An Assessment of the Recount and the Certification of the Election Result for the November 2008 Election

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This report to North Carolina Board of Elections on the November 2008 Sample Recount for the presidential vote consists of two sections. In that election matchup there were a total of 4,310,789 votes cast statewide, of which 2,142,651 (or 49.70%) were for Obama/Biden, 2,128,474 (or 49.38%) for McCain/Palin, 25,722 (or 0.6%) for Barr/Root, and 13,942 (or 0.32%) were "write-in" votes. We begin with a brief description of observations made from the November 2008 sample recount data. Then we present findings from descriptive analyses (based on weighted estimates) of the November 2008 recount data. Finally we provide statistical evidence to quantitatively certify the outcome of the presidential election results for the State of North Carolina in 2008.

A: Observations of November 2008 Sample Recount Process

In our previous work on the election recount projects, we have identified a variety of irregularities (see Kalsbeek & Zhang, 2006, 2008; Kalsbeek, Zhang & Sun, 2008). For example, there were counties that either omitted one of the selected sample precincts in its recount process or supplied more recount data than required. There was also a situation in which one county ignored the sample selected by us and conducted recounts on a sample they had selected. This time we did not see any irregularities in the November 2008 data set.

B: Findings from Descriptive Analyses of November 2008 Recount Data

Descriptive analyses of the November 2008 recount data followed the same approach as our analyses of May 2006, November 2006, and May 2008 recount data. All of the most recent analyses were completed using a data file of the 275 sample precincts/places, and all findings took into account the type of design this sample turned out to be (i.e., a stratified without-replacement simple random sample of precincts/places, within the 100 NC counties serving as sampling strata). The number of samples selected from each county varied from two precincts/places to eleven precincts/places based on the magnitude of discrepancies between total election votes and recount votes in each county observed in the May 2008 recount data. All findings again are sample-based estimates of what would have been observed in the state had all 3,197 precincts/places been recounted. Since only 275 of the 3,197 precincts/places were actually chosen and observed, these findings were estimates and are subject to sampling error, which was measured but not reported in the tables. The standard error (SE) of most estimates is available in the attached analysis output from SUDAAN. Note that SE findings are also estimates and thus subject to sampling error as well, particularly when sample sizes are less than 50. Most findings are presented for the state as a whole and broken down separately by the type of voting equipment used.

1. *Profile of Candidate Vote Count Discrepancies at the Precinct Level* --- In each sample precinct/place we computed the Discrepancy in Candidate Count (DCC)

for the candidate in the precinct/place (i.e., the recounts minus the reported election vote counts) to profile the magnitude and direction (greater or less) that the recounts differed from the election vote counts. A positive discrepancy indicates that the candidate recount was greater than the corresponding candidate election count, while a negative discrepancy indicates that the candidate recount was lower by that amount. The findings in Table B.1 are population estimates of the percent distribution of the values of DCC. These profiles are presented by the type of voting machine used in the precinct/place.

- *See Table B.1 and Attachment B.1* --- Contains tabular findings; and the computer printout of the findings from a sample analysis statistical program package called SUDAAN.

Table B. 1 Percent Distribution of Discrepancies in Candidate Vote Counts (DCC) at the Precinct/Place Level

					Value	Of	DCC						Precinct/ Place Sample Size
Candidate[1]	-5	-3	-2	-1	0	1	2	3	4	5	7	25	
	All Machines Combined												275
1				0.22	96.06		3.72						
2		0.15	0.52	3.00	88.83	4.37	0.72		2.28	0.13			
3	0.4	1.02	0.12	1.82	84.99	8.25	1.34	0.29			0.09	1.68	
4			0.13	0.63	95.75	1.56	0.22				1.7		
	M100 Machines Only												221
1				0.31	94.45		5.25						
2		0.21	0.19	4.23	84.79	6.17	1.01		3.22	0.19			
3	0.56	1.15	0.17	2.09	79.59	11.64	1.89	0.41			0.13	2.37	
4			0.19	0.89	94.5	1.71	0.31				2.4		
	iVotronic Machines Only												54
1					100.00								
2			1.33		98.67								
3		0.69		1.17	98.14								
4					98.81	1.19							
	Manual[2] Only												2
1					100.00								
2					100.00								
3					100.00								
4					100.00								

Note. 1. Presidential Candidates: 1 = Barr, 2 = McCain, 3 = Obama, 4 = Write-in.
2. In Casewell and Perquimans counties, all mail-in absentee ballots were counted and recounted manually.

- *Summary of Findings* --- These figures are in estimated percent of all candidate counts with a discrepancy in the amount indicated. Some of the key findings from Table B.1 are:

    a. It is estimated that election candidate counts varied from -5 to +25 votes from those that would be observed in a recount of all votes cast, with between 84.99% and 96.06% of candidate counts in the precincts/places having no discrepancy among the four candidates in the race.

    b. Candidate count discrepancies were generally greater for M100 machines than for iVotronic machines, with vote count discrepancies varying from -5 to +25 votes for M100 machines and from -3 to +1 votes for iVotronic machines.

2. *Profile of Total Vote Count Discrepancies at the Precinct Level* --- In each sample precinct/place we used the Discrepancy in Total Count (DTC) for the precinct/place (i.e., the total recounts minus the total election vote counts) to profile the magnitude and direction (greater or less) that the total vote recount for the precinct/place differed from the total election vote count for the same precinct/place. The figures in Table B.2 are population estimates of the percent distribution of the values of DTC. Similarly, a positive discrepancy indicates that the candidate recount was greater than the corresponding candidate election count, while a negative discrepancy indicates that the candidate recount was smaller by that amount. These profiles are also presented by the type of voting machine.

    - *See Table B.2 and Attachment B.2* --- Contains tabular findings; and the computer printout of the findings from a sample analysis statistical program package called SUDAAN.

Table B. 2 Percent of Discrepancies in Total Counts (DTC) at the Precinct/Place Level

	Value of DTC											Precinct/Place Sample Size
	-5	-3	-2	-1	0	1	2	3	4	11	38	
All Machines Combined	0.64	0.66	0.76	2.83	78.35	9.87	3.08	1.01	1.02	0.09	1.68	275
M100 Machine Only	0.9	0.64	0.52	3.99	70.29	13.93	4.35	1.43	1.44	0.13	2.37	221
iVotronic Machine Only		0.69	1.33		97.98							54
Manual Only					100							2

- *Summary of Findings* --- These figures are in estimated percent of all total precinct/place counts with a discrepancy in the amount indicated. Some of the key findings from Table B.2 are:

    a. Total precinct/place vote count discrepancies, computed as the sum of the corresponding candidate vote count discrepancies for individual precincts/places and as seen in Table B.2, varied to a greater extent overall than the corresponding candidate vote count discrepancies in Table B.1.

    b. It is estimated that total precinct vote count discrepancies among all machines in the state's precincts/places varied from -5 to +38 votes out of those cast in precincts/places.

    c. Total precinct/place vote count discrepancies for M100 machines were substantially greater (-5 to +38 votes, and 70.29% with no discrepancy) than for iVotronic machines (-3 to 0 votes, and 97.98% with no discrepancy) and for Manual counting (100% with no discrepancy).

3. *Estimated Percent of Precinct Candidate Vote Counts That Are Discrepant* --- We employed the Indicator of Discrepancy for the Candidate Count (IDCC) for the precinct/place to reveal whether or not there was a discrepancy at the precinct level between the recount and the election count for the candidate. Using values of IDCC for all candidate counts in all sample precincts, we produced the results found in Table B.3, where one finds population estimates of the percent of candidate vote counts with a discrepancy. These percentage rates indicate the chances of a discrepancy in the candidate vote counts in the election. These rates are presented by the type of voting machine as well.

    - *See Table B.3 and Attachment B.3* --- Contains tabular findings, and the computer printout of the findings from a sample analysis statistical program package called SUDAAN.

Table B. 3 Estimated Percent of Discrepant Precinct Candidate Vote Counts

Candidate*	All Machines Combined	Precinct/ Place Sample Size	M100 Machine Only	Precinct /Place Sample Size	iVotronic Machine Only	Precinct /Place Sample Size	Manual Only	Precinct /Place Sample Size
1	3.94	275	5.55	221	0.00	54	0.00	2
2	11.17	275	15.21	221	1.33	54	0.00	2
3	15.01	275	20.41	221	1.86	54	0.00	2
4	4.25	271	5.50	219	1.19	52	0.00	2

**Note*. Presidential Candidates: 1 = Barr, 2 = McCain, 3 = Obama, 4 = Write-in.

- *Summary of Findings* --- These figures are in estimated percent of all candidate counts in all precincts/places. Some of the key findings from Table B.3 are:

    a. It is estimated that the percent of discrepant candidate vote counts from all machines varied from 3.94% to 15.01% among the four candidates.

    b. Candidate vote count discrepancy rates among precincts were generally higher for the M100 machines (5.50% to 20.41% among candidates) than for the iVotronic machines (0.00% to 1.86%).

4. *Estimated Percent of Precinct Total Vote Counts That Are Discrepant* --- Once again we used the Indicator of Discrepancy for the Total Count (IDTC) to reveal whether or not there was a discrepancy between the recount and the total election count for the precinct/place. Using values of IDTC for all total precinct/place counts in the sample, we produced the results found in Table B.4, where one finds population estimates of the percent of candidate total precinct/place counts with a discrepancy. These percentage rates indicate the chances of a discrepancy in the total precinct/place vote counts in the election. These rates are also presented by the type of voting machine.

    - *See Table B.4 and Attachment B.4* --- Contains tabular findings; and the computer printout of the findings from a sample analysis statistical program package called SUDAAN.

Table B. 4 Estimated Percent of Discrepancies in Total Count at the Precinct/Place Level

All Machines Combined	Precinct/ Place Sample Size	M100 Machine Only	Precinct/ Place Sample Size	iVotronic Machine Only	Precinct /Place Sample Size	Manual Only	Precinct/ Place Sample Size
21.65	275	29.71	221	2.02	54	0.00	2

- *Summary of Findings* --- These figures are in estimated percent of all precincts/places. Some of the key findings from Table B.4 are:

    a. Total election vote count discrepancy rates among precincts/places for all machines combined and for M100 (Table B.4) fairly differed from corresponding rates among candidates (see Table B.3) in that a good amount of variations in election count discrepancy rates was observed in the counts of M100 machines.

    b. Once again, total precinct/place recounts for M100 machines were much more likely to be discrepant from their election counts (29.71%) than were recounts for iVotronic machines (2.02%) and recounts for manual counting (0.00%).

5. *Estimated Ratios of Undervotes and Overvotes in the Total Vote Counts Statewide* --- This statistical measurement we computed was used to compare the accuracy of voting machines: M100 and iVotronic. We used two measures, that is, undervotes and overvotes in the total counts statewide to assess the accuracy. "Undervotes" are defined as the negative differences between the election counts and the recounts when subtracting recounts from election counts and "overvotes" are the positive differences when subtracting recounts from election counts. Using values of the undervotes and overvotes for all total precincts/places, we produced the results found in Table B.5, where one finds population estimates of the proportion of undervotes/overvotes contributed by M100 machines and iVotronic machines in the election. These ratio estimates indicated that the percentage of the total votes was undercounted or over-counted.

   - *See Table B.5 and Attachment B.5* --- Contains tabular findings and the computer printout of the findings from a sample analysis statistical program package called SUDAAN.

Table B. 5 Ratio estimates for undervotes/overvotes in M100 and iVotronic and total votes

Voting machine	Sample size*	Ratio estimate	Standard Error	t-test	p-value
Undervote					
M100	221	0.00071	0.00014	5.07	0.000
iVotronic	54	0	0		
Total	273	0.00059	0.00017		
Overvote					
M100	221	0.00007	0.00004	0.35	0.724
iVotronic	54	0.00005	0.00004		
Total	273	0.00006	0.00003		

**Note*. The sample sizes for M100 and iVotronic are overlapping for 2 precincts/places.

   - *Summary of Findings* --- These figures are in estimated ratios of all precincts/places. "Student's" t-test was conducted for undervotes and overvotes respectively to compare if M100 machines performed statistically significantly different from iVotronic machines. Some of the key findings from Table B.5 are:

      a. M100 machines were more likely to undercount the election votes than iVotronic machines, which is indicated by the value of t-test (5.07) and *p*-value ($p = 0.000$).

b. M100 machines were not more or less likely as iVotronic machines to overcount the election votes, which is indicated by the value of t-test (0.35) and *p*-value ($p = 0.724$).

c. It seems that M100 machines tend to undercount the election votes. Yet due to a relatively small number of iVotronic machines in the sample, the claim that iVotronic machines perform better than M100 machines was not firmly grounded. Finally, the proportions of undervotes and overvotes in the total election counts were different (0.00059 vs. 0.00006).

Comparison among the Findings from the May 2006 Sample, the November 2006 Sample and the May 2008 Sample

Compared with the May 2006 sample (Kalsbeek & Zhang, 2006), the November 2008 sample showed similar discrepancies in election counts on most of indicators. Then compared with and the November 2006 sample (Kalsbeek & Zhang, 2007), the November 2008 sample showed smaller discrepancies. About 95% of the discrepancies in candidate votes concentrated around -1 to +1 in November 2008 sample, while in the May 2006 sample, all discrepancies varied around -2 to +3, the November 2006 sample around -5 to +5. Variation in total counts at the precinct/place level was greater in the November 2008 sample than in the May 2006 sample, and smaller than in the November 2006 sample. Variations in the November 2008 sample ranged from -5 to +38, while they were from -4 to +4 in the May 2006 sample, and from -13 to +172 in the November 2006 sample. Yet the agreement in the total counts tallied by iVotronic was greater in the November 2008 sample than in the May 2006 sample (97.98% vs. 90.50%) and in the November 2006 sample (97.98% vs. 96.29%). Additionally, an increase was observed in the population estimates of the percent of candidate vote counts (i.e., IDCC) with a discrepancy in the November 2008 sample, with regard to the same estimates in the May 2006 sample. These percentage rates varied from 3.94% to 15.01% across the candidates (Table B.3), whereas in the May 2006 sample these rates ranged from 2.7% to 7.6%. Yet it was a decrease on the same estimates if the November 2008 sample was compared with the November 2006 sample, which the percentage rates ranged from 10.34% to 19.90%. Estimated percentage of candidate total precinct/place counts (i.e., IDTC, see Table B.4) with a discrepancy increased from the May 2006 sample/the November 2006 sample to the November 2008 sample (i.e., May 2006,17.4% vs. November 2008, 21.65%; November 2006,19.84% vs. November 2008, 21.65%).

Compared with the May 2008 sample (Kalsbeek, Zhang, & Sun, 2008), the November 2008 sample showed somewhat similar discrepancies in election counts on most of indicators. About 95% of the discrepancies in candidate votes concentrated around -1 to +1, while in the May 2008 sample, virtually all discrepancies varied around -2 to +1. Variation in total counts at the precinct/place level was greater, ranging from -5 to +38, while the same measure in the May 2008 sample was from -9 to +7. Yet the agreement in the total counts tallied by iVotronic was greater in the May 2008 sample than in the November 2008 sample (99.60% vs. 97.98%). Moreover, a slight increase was observed in the population estimates of the percent of candidate vote counts (i.e., IDCC) with a

discrepancy in the November 2008 sample. These percentage rates varied from 3.94% to 15.01% across the candidates (see Table B.3), whereas in the May 2008 sample these rates ranged from 1.11% to 9.31%. Estimated percentage of candidate total precinct/place counts (i.e., IDTC, see Table B.4) with a discrepancy increased from the May 2008 sample to the November 2008 sample (i.e., 15.64% vs. 19.84%).

A consistent pattern merged from these four samples. M100 machines continued showing more discrepancies in election counts than iVotronic machines. However, the analysis conducted specifically to compare the accuracy of M100 and iVotronic did not lend strong support to the claim that iVotronic outperforms M100 with regard to election count accuracy (see Table B.5).

C: Election Certification from the May 2008 Sample Recounts

Following methodology we recently developed for use with sample recount data starting with the May 2008 primary election [see *Attachment A*], we are able to quantitatively certify the outcome of elections in the State of North Carolina. The measure we obtain in using our methodology is the statistical probability that the declared winner on Election Day in fact defeated the Election Day "loser" (i.e., literally, the second-place finisher in any race with two or more candidates). This result is obtained from the reported election results for the state as a whole and the results of a manual recount in a random sample of the State's "precincts"[1] with the manual count presumed to be the "true" count of votes. The "Election Day" winner and loser defined here are the winner and loser, respectively, based on the statewide vote count on Election Day. Also, we define the "actual" winner and loser as the winner and loser, respectively, based on a complete manual vote recount in all precincts in the state.

If this probability exceeds some reasonable threshold, then the election results can be considered certified. If, for example, the certification threshold is set at 99.9%, then another way of interpreting a certified election is that there is less than a 1 in 1,000 chance that the declared loser based on the Election Day results should have been declared the (actual) winner. While we will arbitrarily adopt 99.9% as the threshold in this report, clearly there should be some consideration by the North Carolina Board of Elections as to what the threshold should be for future election recounts.

Since a manual recount is in reality only available in the randomly selected precincts, actual statewide counts for the candidates are unknown, but they can be estimated from the recount sample since random selection is used to choose the sample. The approach for doing this is now briefly summarized based on Attachment A.

1. *Calculate the probability that the Election Day winner is the actual winner:* In each sample precinct we used the discrepancy between the Election Day count

[1] Voting places in North Carolina include both "precincts," where people go to vote on Election Day, as well as other "places" where they can return ballots cast prior to Election Day. For simplicity, we refer to all both types of ballot assembly points here as "precincts."

and recount for the winner to profile the magnitude and direction that the recount for the precinct differed from the reported vote count for the winner for the same precinct. A positive discrepancy indicates that the recount is greater than the Election Day count, while a negative discrepancy indicates the Election Day count is greater than the recount.[2] The mean discrepancy among all of the State's precincts is then estimated from the sample precincts. We refer to this estimate as $\overline{d}_W$. To determine the probability that the Election Day winner is in fact the actual winner, we need to know how large the average discrepancy must be among all precincts in the state to overturn the Election Day results for the winner and loser. We refer to this outcome-altering average discrepancy amount as $\overline{D}_0$. Assuming that $\overline{d}_W$ follows a Student's t-distribution among all possible precinct samples that we could have chosen, the probability that the Election Day winner is the actual winner is, $\pi_W = \Pr\{\overline{d}_W^* \leq \frac{\overline{D}_0 - \overline{d}_W}{se(\overline{d}_W)}\}$, where $se(\overline{d}_W)$ is the standard error of $\overline{d}_W$, which measures how variable $\overline{d}_W$ is among all possible precinct samples that could have been chosen.

- *See Attachment C.1*---Contains tabular findings, followed immediately by the computer printout of the findings from a sample analysis and statistical analysis program package called SAS-callable-SUDAAN.

- *Summary of findings*---Table C.1 shows the estimated $\overline{d}_W$, standard error of $\overline{d}_W$ (se($\overline{d}_W$)), $\overline{D}_0$, π_W and the probability that the Election Day loser defeated winner. The key findings are:

    a. Compared to $\overline{D}_0$, $\overline{d}_W$ is relatively small, thus the probability that the Election Day winner defeated loser approaches to 1, and the probability that Election Day loser defeated winner approaches to 0, which clearly shows that the Election Day winner is the actual winner.

    b. Using three different options to compute $\overline{D}_0$, we obtained similar values for probability π_W.

[2] Notice that "discrepancy" between Election Day reported and recount numbers in this section is different from the way "discrepancy" was defined in the previous descriptive findings. Discrepancy in this section = Recount – Reported, while Discrepancy in the descriptive findings = Reported – Recount.

Table C.1 Probability for the Election Day Winner Defeated the Loser

Different Options in Computing $\overline{D}_0$	Estimated Mean Discrepancy ($\overline{d}_W$)	Standard Error for Estimated Mean Discrepancy ($se(\overline{d}_W)$)	Value for the Election Day Loser to be Actual Winner ($\overline{D}_0$)	Probability Election Day Loser Is the Actual Winner ($1-\pi_W$)	Probability Election Day Winner Is the Actual Winner (π_W)
1	0.4736	0.4124	2.217	0.000018985	0.99998
2	0.4736	0.4124	1.953	0. 000215924	0.99978
3	0.4736	0.4124	550.123	$\leq$0.0001E-309*	0.99999+

We can conclude from these results that the statistical probability that Obama in fact defeated McCain in the North Carolina election is higher than 99.9 percent.

2. *The 95% confidence interval for estimated total actual vote for the Election Day winner and loser:* Since manual recount is only available in selected precincts, the total actual vote count is unknown. However, we can estimate this vote count and provide a 95% confidence interval for this actual total vote count. If the reported total vote count is within this 95% confidence interval, we then can claim the reported total vote count is correct and can represent the actual total vote count. Based on the total number of recount for the winner and loser in selected precincts, we are able to calculate an estimate for the total number of recount for the whole state and the estimated standard error of this point estimate for winner and loser respectively by using *proc ratio* in SUDAAN. Then the 95% confidence interval for total actual vote count is computed using the point estimate and its estimated standard error by SAS.

    - *See Attachment C.2*---Contains tabular findings and graph, followed immediately by the computer printout of the findings from a sample analysis and statistical analysis program package called SAS-callable-SUDAAN.

    - *Summary of findings*---Table C.2 shows the estimated total recount and its 95% confidence interval for all precincts statewide. The key findings are:

        a. The estimated total recount numbers are very close to the reported vote count for the winner and the loser respectively.

        b. The estimated total recount number for the winner is bigger than the number for the loser.

        c. The reported total counts for winner and loser are a little lower than the computed 95% confidence intervals of estimated total recount respectively. The fact that the number for recount is bigger than reported count makes the estimated total recount higher than reported total count. Also due to relatively small standard error for estimated total recount, 95% confidence

intervals for estimated total recounts do not include the reported total counts for both winner and loser. Thus the reported total count may not be very accurate based on audit data. However, notice the fact that the estimated total recount for the Election Day winner is higher than the loser, and the reported total counts are not far from the 95% confidence interval, we can still certify the result of this election and claim that Obama is the actual winner.

Table C.2 95% Confidence Interval for Actual Total Vote Recount in Winner and Loser

	Reported Total Count[3]	Estimated Total Recount	95% Confidence Interval For Total Recount	
			Lower	Upper
Winner (Obama)	2,142,651	2,143,927.18	2,143,034.73	2,144,819.62
Loser (McCain)	2,128,474	2,128,818.10	2,128,549.26	2,129,086.95

References:

Kalsbeek, W. & Zhang, L. (July, 2006). An Assessment of the May 2006 Election Recount and a Proposed Permanent Recount Sample Design. Work report to North Carolina State Board of Elections.

Kalsbeek, W. & Zhang, L. (May, 2007). An Assessment of the November 2006 Election Recount. Work report to North Carolina State Board of Elections.

Kalsbeek, W., Zhang, L., & Sun, H. (August, 2008). An Assessment of the Recount and the Certification of the Election Result for the May 2008 Primary Election. Work report to North Carolina State Board of Elections.

[3] Numbers presented in this column come from the report of primary election downloaded from the website of North Carolina State Board of Election: http://www.sboe.state.nc.us/content.aspx?id=69

Attachment A

Certification Methodology for North Carolina Elections

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Background

The North Carolina Board of Elections conducts primary elections in May and a general election in November on even numbered years. In 2005 the North Carolina Legislature passed a law requiring: (i) that an audit of the vote count for statewide races be conducted immediately after the election, and (ii) that the audit be done on a random sample of precincts.[4] The legislation also specifies only that at least one precinct must be selected in each of North Carolina's 100 counties. There is no indication as to how, or for what purpose, the audit sample data are to be analyzed, however.

The Survey Research Unit has a standing agreement with the NCBOE to design and choose the sample of precincts/places for the audit for each election. The SRU (by default) has also been given the task of analyzing the data from the audit sample. The sample for the first audit was a stratified simple random sample of 200 precincts/places, with two precincts/places selected in each county, which served as strata.[5] The sample size for each county stratum in the November 2006 general election was determined by the size of the discrepancy in total count (DTC) in the May 2006 sample of precincts for all candidates in the vote for the statewide office designated for audit in that county. Specifically, the number of sampled precincts in the November 2006 election audit for any county was two plus the sum of the magnitude (i.e., absolute value) of the DTCs for the May 2006 sample precincts in the county. This rule led to a November 2006 audit sample size of 264 precincts statewide.

With no directive on what to analyze in these two election audit samples, we simply profiled the size of discrepancies between reported and audit counts for individual candidates and all candidates combined. We also compared the size of discrepancies between the two types of voting machines used in the state (i.e., M100 and iVotronic) and found in both election samples that one (the M100) generally had larger discrepancies.

Objective

In addition to randomly selecting a sample of precincts for the audit recount of designated statewide races in North Carolina elections, and producing simple comparative profiles of discrepancies between the reported vote counts and the recounts, the SRU has agreed to develop a quantitative measure to aid in "certifying" the outcome of designated races in each election. This measure should be based solely on the reported election results in all precincts of the state and on the manual recount results for a random sample of precincts that is chosen by SRU staff the day after the election votes have been reported. Since the SRU is not at all involved in the recount process, we presume: (i) that all statutory requirements are met in completing the recount and (ii) that the recount

[4] A race in any election is consider "statewide" if voters in the state can vote for the candidates running in it. A "precinct" refers to a place where voters go to vote on election day or where absentee ballots can be returned in advance of the election. There were 3,015 precincts established for use in the May 2008 primary election.

[5] Stratification by county is the only way to assure that at least one precinct is selected in each county, and two is the minimum stratum size needed to measure the statistical precision of estimates from the sample.

results can be considered to be the best available "actual" count of the votes (i.e., the recount results are assumed to be error-free).

The methodology we have developed presumes that there are $K \geq 2$ candidates in each designated statewide race. It focuses exclusively on the top two finishers in the designated race. We consider the candidate with the most votes in the race to be the "winner," and the candidate with the second largest number of votes to be the "loser." The winner and loser based on the total statewide reported votes for each candidate on Election Day will be defined as the "apparent" winner and loser, respectively, while the winner and loser based on a (hypothetical) complete manual vote recount in all precincts in the state is defined as the "rightful" winner and loser, respectively. Since the manual recount will only be available for a random sample of precincts, the rightful winner and loser are unknown but can be estimated from the recount sample. The authenticity measure proposed here for each race is the probability that the apparent winner in fact defeated the apparent loser. We describe the approach in detail after defining the notation needed to describe it.

Notation

The table below defines the various terms that are used in the approach:

Symbol	**Definition**
C	Number of counties with at least one precinct in the race; these counties are sampling strata since by law an independent random sample (we use SRS) of precincts/places is chosen in each county *(*$C = 100$ in North Carolina*)*
c	The integer subscripts to designate county $(c = 1,2,\ldots,C)$
N_c	Number of precincts/places in the race in county *c*
$N = \sum_{c=1}^{C} N_c$	Total number of precincts/places in the state (e.g., 3,035 for the November 2006 general election)
n_c	Number of precincts/places selected by SRS in county *c*
$n = \sum_{c=1}^{C} n_c$	Total sample size of precincts/places in the state (e.g., 264 for the November 2006 general election audit sample)
v_{kp} ; v_{Wp} ; v_{Lp}	Election Day vote count for candidate *k* in precinct *p*; for $k=W$ (the Election Day winner); for $k=L$ (the Election Day loser)

Notation	Definition
V_W , V_L	Total reported vote for the Election Day winner (V_W); and total reported vote for the Election Day loser (V_L) [6]
$V = V_W + V_L$	Total reported vote combined for the winner and loser
a_{kp} ; a_{Wp}; a_{Lp}	Actual recount vote for candidate *k* in precinct *p*; for $k=W$ (the Election Day winner); for $k=L$ (the Election Day loser)
A_W , A_L	Total "actual" vote for the Election Day winner (A_W); and total reported vote for the Election Day loser (A_L)
$A = A_W + A_L$	Total "actual" vote combined for the winner and loser
$d_{Wp} = a_{Wp} - v_{Wp}$	Discrepancy between actual (audit) vote count and the Election Day vote count for the Election Day winner in precinct *p*
$D_W = \sum_{p=1}^{N} d_{Wp}$	Total discrepancy among all *N* precincts/places in the state
$\bar{D}_W = \sum_{p=1}^{N} d_{Wp} / N = D_W / N$	Mean discrepancy among all *N* precincts/places in the state
$\omega_{cp} = N_c / n_c$	Sample weight for all n_c sample precincts/places in county *c*
$\bar{d}_W$	Usual stratified SRS estimator of a population mean (of d_{Wp})
$se(\bar{d}_W)$	Usual stratified SRS estimator of the standard error of an estimated population mean (of d_{Wp})

[6] In races with > 2 candidates (see last section), the "loser" will be the 2nd place finisher and the test will be for the correct placement of the 1st and 2nd place finishers in the race.

Approach

We use v_{kp} to denote the vote count reported for candidate *k* in precinct *p*, and a_{kp} denotes the actual vote count for candidate *k* in precinct *p* if a manual audit recount was conducted there. $V = V_W + V_L$ is the total combined reported vote count for the apparent winner and loser in the state's *N* precincts, where $V_W = \sum_{p=1}^{N} v_{Wp}$ and $V_L = \sum_{p=1}^{N} v_{Lp}$ are the statewide reported vote counts for the apparent winner and loser, respectively. If a recount were conducted statewide to determine the actual vote count for all candidates in the *N* precincts, $A = A_W + A_L$ would be the total combined statewide actual vote count for the apparent winner and loser, where $A_W = \sum_{p=1}^{N} a_{Wp}$ and $A_L = \sum_{p=1}^{N} a_{Lp}$ are the statewide actual vote counts for the apparent winner and loser, respectively. Finally, define $d_{Wp} = a_{Wp} - v_{Wp}$ as the discrepancy between the reported and actual vote count for the apparent winner so that $D_W = \sum_{p=1}^{N} d_{Wp} = V_W - A_W$ is the total statewide discrepancy between reported and actual vote counts for the apparent winner and $\bar{D}_W = \sum_{p=1}^{N} d_{Wp} / N = D_W / N$ is the mean discrepancy among precincts in the state.

We are interested in the event (ξ_{WW}) that the apparent winner is the rightful winner of the statewide election. If *A* were known, ξ_{WW} will occur if the sum of discrepancies in all precincts (D_W) is no greater than the difference between the statewide vote count for the apparent winner (V_W) and the minimum actual statewide vote count the apparent winner must have to be considered the rightful winner of the election (i.e., $Int\{ A^* / 2 \}+1$, where in general $Int\{ X \}$ is the integer portion of the numerical value *X)* and A^* is a suitable proxy value for *A* (see options below). Thus, we might test the null hypothesis, $H_o : D_W \le D_o$ where $D_o = V_W - [Int\{ A^* / 2 \}+1]$, against the alternative hypothesis, $H_A : D_W > D_o$; or equivalently we can test $H_o : \bar{D}_W \le \bar{D}_o$ and $H_A : \bar{D}_W > \bar{D}_o$, where $\bar{D}_o = \left[V_W - [Int\{ A^* / 2 \}+1] \right] / N$.

A second approach is to estimate $\bar{D}_W$ from the sample of *n* recount precincts and to determine the probability that $\bar{D}_W$ will be no greater than the value that would make the apparent loser the rightful winner. Once again a proxy value for *A* (i.e., A^*) is needed. Using standard formulae for estimation from a stratified simple random sample, the estimator of $\bar{D}_W$ will be,

$$\bar{d}_W = \sum_{c=1}^{C}(N_c / N)\bar{d}_{Wc} = \frac{\sum_{c=1}^{C}\sum_{p=1}^{n_c}(N_c / n_c)d_{Wcp}}{N} = \frac{\sum_{c=1}^{C}\sum_{p=1}^{n_c}(N_c / n_c)d_{Wcp}}{\sum_{c=1}^{C}\sum_{p=1}^{n_c}(N_c / n_c)} \quad , \qquad [1]$$

where the two ratio expressions are the usual weighted estimator of a mean in SUDAAN *proc descript*, with N_c / n_c as the weight for each sample member, *design=strwor* as the design option in the proc statement, and the created variable, the *nest* statement as *nest county*; with the variable, *county*, as the stratum identifier for the sample precinct, and *N_c*, taking values N_c depending on the county *(c)* from which the sample precinct was selected for the *totcnt* statement. The corresponding estimated variance of $\bar{d}_W$ is compute by this same SUDAAN setup as,

$$[se(\bar{d}_W)]^2 = \sum_{c=1}^{C}\left(\frac{N_c}{N}\right)^2 \frac{1-n_c/N_c}{n_c}\ s^2_{wc} = \sum_{c=1}^{C}\left(\frac{N_c}{N}\right)^2 \frac{1-n_c/N_c}{n_c}\ \frac{\sum_{p=1}^{n_c}(d_{Wcp}-\bar{d}_{Wc})^2}{n_c-1} \qquad [2]$$

If we can assume that $\bar{d}_W$ follows a *"Student's" t-distribution* with *n-C* degrees of freedom with mean, $\bar{D}_W$, and variance, $V(\bar{d}_W)$, then another direct certification indicator for the statewide race that is audited is the following probability that the apparent winner in fact defeated the apparent loser; i.e.,

$$\pi_W \equiv Pr\left\{\bar{d}_W \le \bar{D}_o\right\} = Pr\left\{\bar{d}_W \le \frac{\{V_W - [Int\{A^*/2\}+1]\}}{N}\right\} , \qquad [3]$$

where A^* is a proxy measure of *A*. Obtaining the expression in Eq. [3] requires a transformation of $\bar{d}_W$ (referred to as $\bar{d}^*_w$) that will follows a standard *t-distribution* with mean zero and unit variance. The probability that the apparent winner in fact defeated the apparent loser, as obtained from $\bar{d}^*_w$, will thus be,

$$\pi_W \equiv Pr\left\{\bar{d}^*_w \le \frac{\bar{D}_o - \bar{d}_W}{se(\bar{d}_W)}\right\} = Pr\left\{\bar{d}^*_w \le \frac{\{V_W - [Int\{A^*/2\}+1]\}/N - \bar{d}_W}{se(\bar{d}_W)}\right\} . \qquad [4]$$

Both of the above approaches require a measure for *A*, which is unknown. The following are optional values for A^*:

1. $A^* = V$ --- This option assumes that A=V, which assumes that there are no overvotes (commission errors in reported vote count) or undervotes (omission errors in reported vote count) and that any misappropriation of votes to the winner is from the loser, and vice versa. This assumption is risky.

2. $A^* = \hat{A}_c$ --- $\hat{A}_c = V\hat{R}_c = V\dfrac{\hat{A}}{\hat{V}}$ is a combined estimator of *A* obtained from the stratified SRS of precincts. One way to compute $\hat{A}_c$ and its estimated standard error, $se(\hat{A}_c) = V\{se(\hat{R}_c)\}$, is to obtain $\hat{R}_c$ and $se(\hat{R}_c)$ from *proc ratio* in SUDAAN using the total actual winner and loser vote count for each precinct (i.e., $a_p = a_{Wp} + a_{Lp}$), as the numerator variable, the total reported winner and loser vote count from the election for each precinct (i.e., $v_p = v_{Wp} + v_{Lp}$), as the denominator variable, and the same design setup as used to obtain $\bar{d}_W$ and its standard error (see text immediately following Eq. [1]). Since *V* is known, the estimates of $\hat{A}$ and $se(\hat{A}_c)$ follow directly from the fact that $\hat{A}_c = V\hat{R}_c$ and $se(\hat{A}_c) = V\{se(\hat{R}_c)\}$.

3. $A^* = \hat{A} - 1.96\{se(\hat{A})\}$ --- Using the lower bound of a 95% confidence interval for *A* is almost certain to produce the most conservative value for π_W.

Using Eq. [4], produce π_W the probability that the apparent winner in fact defeated the apparent loser using all three options for A^*.

Attachment B.1

Attachment B.2

Attachment B.3

Attachment B.4

Attachment B.5

Attachment B.1

Profile of Discrepancies of Candidate Count (DCC)

```
                              S U D A A N
           Software for the Statistical Analysis of Correlated Data
          Copyright        Research Triangle Institute          July 2004
                                 Release 9.0.0


Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175




Date: 02-03-2009                Research Triangle Institute                  Page  : 1
Time: 14:07:00                     The CROSSTAB Procedure                    Table : 1


Frequencies and Values for CLASS Variables
by: Total diff @candidate1.

----------------------------------
Total diff
  @candidat-
  e1            Frequency    Value
----------------------------------
Ordered
  Position:
  1                     1       -1
Ordered
  Position:
  2                   271        0
Ordered
  Position:
  3                     3        2
----------------------------------
```

Frequencies and Values for CLASS Variables
by: Total diff @candidate2.

Total diff @candidate2	Frequency	Value
Ordered Position: 1	1	-3
Ordered Position: 2	2	-2
Ordered Position: 3	6	-1
Ordered Position: 4	237	0
Ordered Position: 5	20	1
Ordered Position: 6	4	2
Ordered Position: 7	4	4
Ordered Position: 8	1	5

Frequencies and Values for CLASS Variables
by: Total diff @candidate3.

Total diff @candidate3	Frequency	Value
Ordered Position: 1	2	-5
Ordered Position: 2	4	-3
Ordered Position: 3	1	-2
Ordered Position: 4	8	-1
Ordered Position: 5	236	0
Ordered Position: 6	16	1
Ordered Position: 7	4	2
Ordered Position: 8	2	3
Ordered Position: 9	1	7
Ordered Position: 10	1	25

Frequencies and Values for CLASS Variables
by: Total diff @candidate4.

Total diff @candidate4	Frequency	Value
Ordered Position: 1	1	-2
Ordered Position: 2	3	-1
Ordered Position: 3	261	0
Ordered Position: 4	4	1
Ordered Position: 5	1	2
Ordered Position: 6	1	7

Frequencies and Values for CLASS Variables
by: M100 diff @candidate1.

M100 diff @candidate1	Frequency	Value
Ordered Position: 1	1	-1
Ordered Position: 2	217	0
Ordered Position: 3	3	2

Frequencies and Values for CLASS Variables
by: M100 diff @candidate2.

M100 diff @candidate2	Frequency	Value
Ordered Position: 1	1	-3
Ordered Position: 2	1	-2
Ordered Position: 3	6	-1
Ordered Position: 4	184	0
Ordered Position: 5	20	1
Ordered Position: 6	4	2
Ordered Position: 7	4	4
Ordered Position: 8	1	5

Frequencies and Values for CLASS Variables
by: M100 diff @candidate3.

M100 diff @candidate3	Frequency	Value
Ordered Position: 1	2	-5
Ordered Position: 2	3	-3
Ordered Position: 3	1	-2
Ordered Position: 4	7	-1
Ordered Position: 5	184	0
Ordered Position: 6	16	1
Ordered Position: 7	4	2
Ordered Position: 8	2	3
Ordered Position: 9	1	7
Ordered Position: 10	1	25

Frequencies and Values for CLASS Variables
by: M100 diff @candidate4.

M100 diff @candidat-e4	Frequency	Value
Ordered Position: 1	1	-2
Ordered Position: 2	3	-1
Ordered Position: 3	210	0
Ordered Position: 4	3	1
Ordered Position: 5	1	2
Ordered Position: 6	1	7

Frequencies and Values for CLASS Variables
by: iVo diff @candidate1.

iVo diff @candidat-e1	Frequency	Value
Ordered Position: 1	54	0

Frequencies and Values for CLASS Variables
by: iVo diff @candidate2.

iVo diff @candidate2	Frequency	Value
Ordered Position: 1	1	-2
Ordered Position: 2	53	0

Frequencies and Values for CLASS Variables
by: iVo diff @candidate3.

iVo diff @candidate3	Frequency	Value
Ordered Position: 1	1	-3
Ordered Position: 2	1	-1
Ordered Position: 3	52	0

Frequencies and Values for CLASS Variables
by: iVo diff @candidate4.

iVo diff @candidat-e4	Frequency	Value
Ordered Position: 1	51	0
Ordered Position: 2	1	1

Frequencies and Values for CLASS Variables
by: MANUAL diff @candidate1.

MANUAL diff @candidat-e1	Frequency	Value
Ordered Position: 1	2	0

Frequencies and Values for CLASS Variables
by: MANUAL diff @candidate2.

MANUAL diff @candidat-e2	Frequency	Value
Ordered Position: 1	2	0

Frequencies and Values for CLASS Variables
by: MANUAL diff @candidate3.

MANUAL diff @candidat-e3	Frequency	Value
Ordered Position: 1	2	0

Frequencies and Values for CLASS Variables
by: MANUAL diff @candidate4.

MANUAL diff @candidat-e4	Frequency	Value
Ordered Position: 1	2	0

Variance Estimation Method: Taylor Series (STRWOR)
by: Total diff @candidate1.

Total diff @candidate1	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	275	3197.00	100.00	.	.	.
-1	1	7.00	0.22	0.20	0.04	1.35
0	271	3071.17	96.06	1.96	89.75	98.55
2	3	118.83	3.72	1.95	1.30	10.18

Variance Estimation Method: Taylor Series (STRWOR)
by: Total diff @candidate2.

Total diff @candidate2	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	275	3197.00	100.00	.	.	.
-3	1	4.80	0.15	0.13	0.03	0.87
-2	2	16.70	0.52	0.39	0.12	2.28
-1	6	95.80	3.00	1.86	0.87	9.82
0	237	2839.92	88.83	2.83	81.93	93.31
1	20	139.77	4.37	1.25	2.48	7.60
2	4	22.87	0.72	0.37	0.26	1.95
4	4	72.94	2.28	1.71	0.51	9.61
5	1	4.20	0.13	0.11	0.02	0.73

Variance Estimation Method: Taylor Series (STRWOR)
by: Total diff @candidate3.

Total diff @candidate3	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	275	3197.00	100.00	.	.	.
-5	2	12.80	0.40	0.28	0.10	1.62
-3	4	32.50	1.02	0.50	0.39	2.65
-2	1	3.80	0.12	0.10	0.02	0.64
-1	8	58.30	1.82	0.79	0.77	4.23
0	236	2717.11	84.99	2.91	78.30	89.88
1	16	263.64	8.25	2.54	4.43	14.83
2	4	42.92	1.34	0.86	0.38	4.65
3	2	9.30	0.29	0.18	0.08	1.00
7	1	2.89	0.09	0.07	0.02	0.44
25	1	53.75	1.68	1.67	0.23	11.10

Variance Estimation Method: Taylor Series (STRWOR)
by: Total diff @candidate4.

Total diff @candidate4	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	271	3155.00	100.00	.	.	.
-2	1	4.20	0.13	0.12	0.02	0.74
-1	3	19.90	0.63	0.38	0.19	2.03
0	261	3020.82	95.75	1.90	89.95	98.26
1	4	49.33	1.56	0.82	0.55	4.33
2	1	7.00	0.22	0.21	0.04	1.37
7	1	53.75	1.70	1.69	0.24	11.24

Variance Estimation Method: Taylor Series (STRWOR)
by: M100 diff @candidate1.

M100 diff @candidate1	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	221	2265.50	100.00	.	.	.
-1	1	7.00	0.31	0.29	0.05	1.90
0	217	2139.67	94.45	2.77	85.71	97.97
2	3	118.83	5.25	2.76	1.82	14.19

Variance Estimation Method: Taylor Series (STRWOR)
by: M100 diff @candidate2.

M100 diff @candidate2	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	221	2265.50	100.00	.	.	.
-3	1	4.80	0.21	0.19	0.04	1.22
-2	1	4.20	0.19	0.16	0.03	1.03
-1	6	95.80	4.23	2.62	1.22	13.65
0	184	1920.92	84.79	3.95	75.28	91.08
1	20	139.77	6.17	1.76	3.49	10.69
2	4	22.87	1.01	0.52	0.37	2.75
4	4	72.94	3.22	2.42	0.72	13.32
5	1	4.20	0.19	0.16	0.03	1.03

Variance Estimation Method: Taylor Series (STRWOR)
by: M100 diff @candidate3.

M100 diff @candidate3	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	221	2265.50	100.00	.	.	.
-5	2	12.80	0.56	0.40	0.14	2.27
-3	3	26.00	1.15	0.65	0.37	3.48
-2	1	3.80	0.17	0.14	0.03	0.91
-1	7	47.30	2.09	1.01	0.80	5.35
0	184	1803.11	79.59	4.07	70.39	86.48
1	16	263.64	11.64	3.58	6.21	20.75
2	4	42.92	1.89	1.21	0.53	6.52
3	2	9.30	0.41	0.26	0.12	1.41
7	1	2.89	0.13	0.10	0.03	0.63
25	1	53.75	2.37	2.35	0.33	15.26

Variance Estimation Method: Taylor Series (STRWOR)
by: M100 diff @candidate4.

M100 diff @candidate4	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	219	2240.50	100.00	.	.	.
-2	1	4.20	0.19	0.16	0.03	1.04
-1	3	19.90	0.89	0.53	0.27	2.86
0	210	2117.32	94.50	2.64	86.32	97.91
1	3	38.33	1.71	1.05	0.50	5.64
2	1	7.00	0.31	0.29	0.05	1.92
7	1	53.75	2.40	2.38	0.33	15.41

Variance Estimation Method: Taylor Series (STRWOR)
by: iVo diff @candidate1.

iVo diff @candidate1	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	54	940.50	100.00	0.00	.	.
0	54	940.50	100.00	0.00	.	.

Variance Estimation Method: Taylor Series (STRWOR)
by: iVo diff @candidate2.

iVo diff @candidate2	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	54	940.50	100.00	0.00	.	.
-2	1	12.50	1.33	1.27	0.20	8.40
0	53	928.00	98.67	1.27	91.60	99.80

Variance Estimation Method: Taylor Series (STRWOR)
by: iVo diff @candidate3.

iVo diff @candidate3	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	54	940.50	100.00	0.00	.	.
-3	1	6.50	0.69	0.63	0.11	4.10
-1	1	11.00	1.17	1.12	0.18	7.36
0	52	923.00	98.14	1.28	92.98	99.53

Variance Estimation Method: Taylor Series (STRWOR)
by: iVo diff @candidate4.

iVo diff @candidate4	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	52	923.50	100.00	0.00	.	.
0	51	912.50	98.81	1.14	92.51	99.82
1	1	11.00	1.19	1.14	0.18	7.49

Variance Estimation Method: Taylor Series (STRWOR)
by: MANUAL diff @candidate1.

MANUAL diff @candidate1	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	2	11.00	100.00	0.00	.	.
0	2	11.00	100.00	0.00	.	.

Date: 02-03-2009 Research Triangle Institute Page : 30
Time: 14:07:00 The CROSSTAB Procedure Table : 14

Variance Estimation Method: Taylor Series (STRWOR)
by: MANUAL diff @candidate2.

MANUAL diff @candidate2	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	2	11.00	100.00	0.00	.	.
0	2	11.00	100.00	0.00	.	.

Date: 02-03-2009 Research Triangle Institute Page : 31
Time: 14:07:00 The CROSSTAB Procedure Table : 15
Variance Estimation Method: Taylor Series (STRWOR)
by: MANUAL diff @candidate3.

MANUAL diff @candidate3	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	2	11.00	100.00	0.00	.	.
0	2	11.00	100.00	0.00	.	.

Date: 02-03-2009 Research Triangle Institute Page : 32
Time: 14:07:00 The CROSSTAB Procedure Table : 16

Variance Estimation Method: Taylor Series (STRWOR)
by: MANUAL diff @candidate4.

MANUAL diff @candidate4	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	2	11.00	100.00	0.00	.	.
0	2	11.00	100.00	0.00	.	.

Attachment B.2

Profile of Discrepancies of Total Count (DTC)

```
                              S U D A A N
           Software for the Statistical Analysis of Correlated Data
          Copyright        Research Triangle Institute          July 2004
                                 Release 9.0.0

Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175

Date: 02-03-2009                 Research Triangle Institute                    Page  : 1
Time: 14:07:40                      The CROSSTAB Procedure                      Table : 1

Frequencies and Values for CLASS Variables
by: Total diff @ precin.

---------------------------------
Total diff @
  precin        Frequency    Value
---------------------------------
Ordered
  Position:
  1                     2       -5
Ordered
  Position:
  2                     3       -3
Ordered
  Position:
  3                     4       -2
Ordered
  Position:
  4                     8       -1
Ordered
  Position:
  5                   217        0
Ordered
  Position:
  6                    24        1
Ordered
  Position:
  7                     8        2
Ordered
  Position:
  8                     3        3
Ordered
  Position:
  9                     4        4
Ordered
  Position:
  10                    1       11
Ordered
  Position:
  11                    1       38
---------------------------------
```

Frequencies and Values for CLASS Variables
by: M100 diff @ precin.

M100 diff @ precin	Frequency	Value
Ordered Position: 1	2	-5
Ordered Position: 2	2	-3
Ordered Position: 3	3	-2
Ordered Position: 4	8	-1
Ordered Position: 5	165	0
Ordered Position: 6	24	1
Ordered Position: 7	8	2
Ordered Position: 8	3	3
Ordered Position: 9	4	4
Ordered Position: 10	1	11
Ordered Position: 11	1	38

Frequencies and Values for CLASS Variables
by: iVo diff @ precin.

iVo diff @ precin	Frequency	Value
Ordered Position: 1	1	-3
Ordered Position: 2	1	-2
Ordered Position: 3	52	0

Frequencies and Values for CLASS Variables
by: Manual diff @ precin.

Manual diff @ precin	Frequency	Value
Ordered Position: 1	2	0

Variance Estimation Method: Taylor Series (STRWOR)
by: Total diff @ precin.

Total diff @ precin	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	275	3197.00	100.00	.	.	.
-5	2	20.50	0.64	0.43	0.17	2.42
-3	3	21.00	0.66	0.36	0.22	1.93
-2	4	24.30	0.76	0.41	0.26	2.20
-1	8	90.40	2.83	1.83	0.78	9.75
0	217	2504.93	78.35	2.25	73.59	82.46
1	24	315.49	9.87	2.65	5.73	16.47
2	8	98.62	3.08	1.75	0.99	9.19
3	3	32.42	1.01	0.79	0.22	4.62
4	4	32.70	1.02	0.54	0.36	2.85
11	1	2.89	0.09	0.07	0.02	0.44
38	1	53.75	1.68	1.67	0.23	11.10

Variance Estimation Method: Taylor Series (STRWOR)
by: M100 diff @ precin.

M100 diff @ precin	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	221	2265.50	100.00	.	.	.
-5	2	20.50	0.90	0.61	0.24	3.40
-3	2	14.50	0.64	0.43	0.17	2.42
-2	3	11.80	0.52	0.24	0.21	1.29
-1	8	90.40	3.99	2.58	1.09	13.55
0	165	1592.43	70.29	3.12	63.80	76.05
1	24	315.49	13.93	3.74	8.03	23.05
2	8	98.62	4.35	2.47	1.39	12.81
3	3	32.42	1.43	1.11	0.30	6.46
4	4	32.70	1.44	0.76	0.51	4.02
11	1	2.89	0.13	0.10	0.03	0.63
38	1	53.75	2.37	2.35	0.33	15.26

Variance Estimation Method: Taylor Series (STRWOR)
by: iVo diff @ precin.

iVo diff @ precin	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	54	940.50	100.00	0.00	.	.
-3	1	6.50	0.69	0.63	0.11	4.10
-2	1	12.50	1.33	1.27	0.20	8.40
0	52	921.50	97.98	1.42	92.18	99.50

Variance Estimation Method: Taylor Series (STRWOR)
by: Manual diff @ precin.

Manual diff @ precin	Sample Size	Weighted Size	Row Percent	SE Row Percent	Lower 95% Limit ROWPER	Upper 95% Limit ROWPER
Total	2	11.00	100.00	0.00	.	.
0	2	11.00	100.00	0.00	.	.

Attachment B.3

Proc Descript of IDCC

```
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Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175


Date: 02-03-2009                Research Triangle Institute                    Page  : 1
Time: 14:08:03                    The DESCRIPT Procedure                       Table : 1

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.
```

Variable		One
		1
Total dummy-diff @candidate1 1=yes 0=no	Sample Size	275.0000
	Weighted Size	3197.0000
	Total	125.8333
	Lower 95% Limit	
	Total	1.9583
	Upper 95% Limit	
	Total	249.7084
	Mean	0.0394
	SE Mean	0.0196
	Lower 95% Limit	
	Mean	0.0006
	Upper 95% Limit	
	Mean	0.0781
Total dummy-diff @candidate2 1=yes 0=no	Sample Size	275.0000
	Weighted Size	3197.0000
	Total	357.0765
	Lower 95% Limit	
	Total	178.7546
	Upper 95% Limit	
	Total	535.3984
	Mean	0.1117
	SE Mean	0.0283
	Lower 95% Limit	
	Mean	0.0559
	Upper 95% Limit	
	Mean	0.1675

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.

Variable		One
		1
Total dummy-diff @candidate3 1=yes 0=no	Sample Size	275.0000
	Weighted Size	3197.0000
	Total	479.8944
	Lower 95% Limit	
	Total	296.1558
	Upper 95% Limit	
	Total	663.6331
	Mean	0.1501
	SE Mean	0.0291
	Lower 95% Limit	
	Mean	0.0926
	Upper 95% Limit	
	Mean	0.2076
Total dummy-diff @candidate4 1=yes 0=no	Sample Size	271.0000
	Weighted Size	3155.0000
	Total	134.1833
	Lower 95% Limit	
	Total	15.7338
	Upper 95% Limit	
	Total	252.6329
	Mean	0.0425
	SE Mean	0.0190
	Lower 95% Limit	
	Mean	0.0050
	Upper 95% Limit	
	Mean	0.0801

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.

Variable		One
		1
M100 dummy-diff @candidate1 1=yes 0=no	Sample Size	221.0000
	Weighted Size	2265.5000
	Total	125.8333
	Lower 95% Limit	
	Total	1.9583
	Upper 95% Limit	
	Total	249.7084
	Mean	0.0555
	SE Mean	0.0277
	Lower 95% Limit	
	Mean	0.0009
	Upper 95% Limit	
	Mean	0.1102
M100 dummy-diff @candidate2 1=yes 0=no	Sample Size	221.0000
	Weighted Size	2265.5000
	Total	344.5765
	Lower 95% Limit	
	Total	167.8315
	Upper 95% Limit	
	Total	521.3214
	Mean	0.1521
	SE Mean	0.0395
	Lower 95% Limit	
	Mean	0.0741
	Upper 95% Limit	
	Mean	0.2301

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.

Variable		One
		1
M100 dummy-diff @candidate3 1=yes 0=no	Sample Size	221.0000
	Weighted Size	2265.5000
	Total	462.3944
	Lower 95% Limit	
	Total	280.2072
	Upper 95% Limit	
	Total	644.5817
	Mean	0.2041
	SE Mean	0.0407
	Lower 95% Limit	
	Mean	0.1237
	Upper 95% Limit	
	Mean	0.2845
M100 dummy-diff @candidate4 1=yes 0=no	Sample Size	219.0000
	Weighted Size	2240.5000
	Total	123.1833
	Lower 95% Limit	
	Total	6.5564
	Upper 95% Limit	
	Total	239.8102
	Mean	0.0550
	SE Mean	0.0264
	Lower 95% Limit	
	Mean	0.0029
	Upper 95% Limit	
	Mean	0.1070

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.

Variable		One
		1
iVo dummy-diff @candidate1 1=yes 0=no	Sample Size	54.0000
	Weighted Size	940.5000
	Total	0.0000
	Lower 95% Limit	
	Total	0.0000
	Upper 95% Limit	
	Total	0.0000
	Mean	0.0000
	SE Mean	0.0000
	Lower 95% Limit	
	Mean	0.0000
	Upper 95% Limit	
	Mean	0.0000
iVo dummy-diff @candidate2 1=yes 0=no	Sample Size	54.0000
	Weighted Size	940.5000
	Total	12.5000
	Lower 95% Limit	
	Total	-11.1628
	Upper 95% Limit	
	Total	36.1628
	Mean	0.0133
	SE Mean	0.0127
	Lower 95% Limit	
	Mean	-0.0119
	Upper 95% Limit	
	Mean	0.0385

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.

Variable		One 1
iVo dummy-diff @candidate3 1=yes 0=no	Sample Size	54.0000
	Weighted Size	940.5000
	Total	17.5000
	Lower 95% Limit Total	-6.3268
	Upper 95% Limit Total	41.3268
	Mean	0.0186
	SE Mean	0.0128
	Lower 95% Limit Mean	-0.0066
	Upper 95% Limit Mean	0.0438
iVo dummy-diff @candidate4 1=yes 0=no	Sample Size	52.0000
	Weighted Size	923.5000
	Total	11.0000
	Lower 95% Limit Total	-9.6994
	Upper 95% Limit Total	31.6994
	Mean	0.0119
	SE Mean	0.0114
	Lower 95% Limit Mean	-0.0105
	Upper 95% Limit Mean	0.0343

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.

Variable		One
		1
MANUAL dummy-diff @candidate1 1=yes 0=no	Sample Size	2.0000
	Weighted Size	11.0000
	Total	0.0000
	Lower 95% Limit	
	Total	0.0000
	Upper 95% Limit	
	Total	0.0000
	Mean	0.0000
	SE Mean	0.0000
	Lower 95% Limit	
	Mean	0.0000
	Upper 95% Limit	
	Mean	0.0000
MANUAL dummy-diff @candidate2 1=yes 0=no	Sample Size	2.0000
	Weighted Size	11.0000
	Total	0.0000
	Lower 95% Limit	
	Total	0.0000
	Upper 95% Limit	
	Total	0.0000
	Mean	0.0000
	SE Mean	0.0000
	Lower 95% Limit	
	Mean	0.0000
	Upper 95% Limit	
	Mean	0.0000

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.

Variable		One
		1
MANUAL dummy-diff @candidate3 1=yes 0=no	Sample Size	2.0000
	Weighted Size	11.0000
	Total	0.0000
	Lower 95% Limit	
	Total	0.0000
	Upper 95% Limit	
	Total	0.0000
	Mean	0.0000
	SE Mean	0.0000
	Lower 95% Limit	
	Mean	0.0000
	Upper 95% Limit	
	Mean	0.0000
MANUAL dummy-diff @candidate4 1=yes 0=no	Sample Size	2.0000
	Weighted Size	11.0000
	Total	0.0000
	Lower 95% Limit	
	Total	0.0000
	Upper 95% Limit	
	Total	0.0000
	Mean	0.0000
	SE Mean	0.0000
	Lower 95% Limit	
	Mean	0.0000
	Upper 95% Limit	
	Mean	0.0000

Attachment B.4

Proc Descript of IDTC

```
                              S U D A A N
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                                  Release 9.0.0

Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175


Date: 02-03-2009                 Research Triangle Institute                    Page  : 1
Time: 14:08:25                     The DESCRIPT Procedure                       Table : 1

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.
```

Variable		One 1
Total dummy-diff @precin 1=yes 0=no	Sample Size	275.0000
	Weighted Size	3197.0000
	Total	692.0654
	Lower 95% Limit Total	550.1557
	Upper 95% Limit Total	833.9750
	Mean	0.2165
	SE Mean	0.0225
	Lower 95% Limit Mean	0.1721
	Upper 95% Limit Mean	0.2609
M100 dummy-diff @precin 1=yes 0=no	Sample Size	221.0000
	Weighted Size	2265.5000
	Total	673.0654
	Lower 95% Limit Total	533.6409
	Upper 95% Limit Total	812.4898
	Mean	0.2971
	SE Mean	0.0312
	Lower 95% Limit Mean	0.2356
	Upper 95% Limit Mean	0.3586

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.

Variable		One
		1
iVo dummy-diff @precin 1=yes O=no	Sample Size	54.0000
	Weighted Size	940.5000
	Total	19.0000
	Lower 95% Limit	
	Total	-7.4420
	Upper 95% Limit	
	Total	45.4420
	Mean	0.0202
	SE Mean	0.0142
	Lower 95% Limit	
	Mean	-0.0078
	Upper 95% Limit	
	Mean	0.0482
MANUAL dummy-diff @precin 1=yes O=no	Sample Size	2.0000
	Weighted Size	11.0000
	Total	0.0000
	Lower 95% Limit	
	Total	0.0000
	Upper 95% Limit	
	Total	0.0000
	Mean	0.0000
	SE Mean	0.0000
	Lower 95% Limit	
	Mean	0.0000
	Upper 95% Limit	
	Mean	0.0000

Attachment B.5

Proportion of undervotes in total M100 votes

```
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Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175


Date: 02-03-2009                 Research Triangle Institute                    Page  : 1
Time: 14:09:16                       The RATIO Procedure                        Table : 1

Frequencies and Values for CLASS Variables
by: M100.

----------------------------------
M100            Frequency    Value
----------------------------------
Ordered
  Position:
  1                    54        0
Ordered
  Position:
  2                   221        1
----------------------------------


Date: 02-03-2009                 Research Triangle Institute                    Page  : 2
Time: 14:09:16                       The RATIO Procedure                        Table : 1

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, M100.

-------------------------------------------------------------------------------------------
Variable             Sample    Weighted    Weighted     Weighted
   M100              Size      Size        X-Sum        Y-Sum        Ratio Est.  SE Ratio
-------------------------------------------------------------------------------------------
UNDERVOTE/total
  counts for all
  candidates
  @precinct
   Total                273        3186      4771084         2815      0.00059   0.00017
   0                     52         921       823625            0      0.00000   0.00000
   1                    221        2265      3947459         2815      0.00071   0.00014
-------------------------------------------------------------------------------------------
```

Proportion of undervotes in total iVotronic votes

```
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                                 Release 9.0.0


Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175



Date: 02-03-2009                Research Triangle Institute                  Page  : 1
Time: 14:10:15                      The RATIO Procedure                      Table : 1

Frequencies and Values for CLASS Variables
by: IVOTRONIC.

---------------------------------
IVOTRONIC       Frequency    Value
---------------------------------
Ordered
  Position:
  1                   221        0
Ordered
  Position:
  2                    54        1
---------------------------------


Date: 02-03-2009                Research Triangle Institute                   Page  : 2
Time: 14:10:15                      The RATIO Procedure                       Table : 1

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, IVOTRONIC.

-------------------------------------------------------------------------------------------
Variable             Sample    Weighted    Weighted     Weighted
   IVOTRONIC         Size      Size        X-Sum        Y-Sum        Ratio Est.  SE Ratio
-------------------------------------------------------------------------------------------
UNDERVOTE/total
  counts for all
  candidates
  @precinct
   Total                 273        3186      4771084         2815      0.00059   0.00017
   0                     219        2245      3939729         2815      0.00071   0.00014
   1                      54         941       831355            0      0.00000   0.00000
-------------------------------------------------------------------------------------------
```

Proportion of overvotes in total M100 votes

```
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Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175


Date: 02-03-2009                 Research Triangle Institute                  Page  : 1
Time: 14:09:45                       The RATIO Procedure                      Table : 1

Frequencies and Values for CLASS Variables
by: M100.

---------------------------------
M100            Frequency    Value
---------------------------------
Ordered
  Position:
  1                    54        0
Ordered
  Position:
  2                   221        1
---------------------------------




Date: 02-03-2009                 Research Triangle Institute                  Page  : 2
Time: 14:09:45                       The RATIO Procedure                      Table : 1

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, M100.

-------------------------------------------------------------------------------------------
Variable             Sample    Weighted    Weighted     Weighted
   M100              Size      Size        X-Sum        Y-Sum        Ratio Est.  SE Ratio
-------------------------------------------------------------------------------------------
OVERVOTE/total
  counts for all
  candidates
  @precinct
   Total                273        3186      4771084          305      0.00006   0.00003
   0                     52         921       823625           45      0.00005   0.00004
   1                    221        2265      3947459          260      0.00007   0.00004
-------------------------------------------------------------------------------------------
```

Proportion of overvotes in total iVotronic votes

```
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Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175


Date: 02-03-2009                Research Triangle Institute                   Page  : 1
Time: 14:10:51                      The RATIO Procedure                       Table : 1

Frequencies and Values for CLASS Variables
by: IVOTRONIC.

---------------------------------
IVOTRONIC       Frequency    Value
---------------------------------
Ordered
  Position:
  1                   221        0
Ordered
  Position:
  2                    54        1
---------------------------------



Date: 02-03-2009                Research Triangle Institute                   Page  : 2
Time: 14:10:51                      The RATIO Procedure                       Table : 1

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, IVOTRONIC.

-------------------------------------------------------------------------------------------
Variable             Sample    Weighted    Weighted     Weighted
   IVOTRONIC         Size      Size        X-Sum        Y-Sum        Ratio Est.  SE Ratio
-------------------------------------------------------------------------------------------
OVERVOTE/total
  counts for all
  candidates
  @precinct
   Total                 273        3186      4771084          305      0.00006   0.00003
   0                     219        2245      3939729          260      0.00007   0.00004
   1                      54         941       831355           45      0.00005   0.00004
-------------------------------------------------------------------------------------------
```

Attachment C.1

Attachment C.2

Attachment C.1

Mean Discrepancy of the Vote Count for the Election Day Winner (dwp)

```
                                S U D A A N
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Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175



Date: 12-12-2008             Research Triangle Institute             Page  : 1
Time: 16:08:46                 The DESCRIPT Procedure                Table : 1

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.

--------------------------------------------------
|                 |                  |
| Variable        |                  | One
|                 |                  | 1          |
--------------------------------------------------
|                 |                  |            |
| DIFF_OBA        | Sample Size      |   275.0000 |
|                 | Weighted Size    |  3197.0000 |
|                 | Mean             |     0.4736 |
|                 | SE Mean          |     0.4124 |
|                 | DEFF Mean #4     |     4.3533 |
--------------------------------------------------
```

H-T Estimation of A total (Actual Vote Combined for the Winner and Loser)

```
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Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175

Date: 12-12-2008             Research Triangle Institute             Page  : 1
Time: 16:08:46                 The DESCRIPT Procedure                Table : 1

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.
```

Variable		One 1
TOTRECOUNTWL	Sample Size	275.0000
	Weighted Size	3197.0000
	ATOTAL	4737524.2190
	SEATOTAL	2025360.5368

PROC RATIO Step for Estimating Total A

```
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                                 Release 9.0.1

Number of observations read    :    275    Weighted count :     3197
Denominator degrees of freedom :    175

Date: 12-12-2008             Research Triangle Institute             Page  : 1
Time: 16:08:46                     The RATIO Procedure               Table : 1

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.
```

Variable		One 1
TOTRECOUNTWL/TOTCOUNTWL	Ratio Est.	1.000395
	SE Ratio	0.000160
	Weighted Y-Sum	4737524
	Weighted X-Sum	4735656

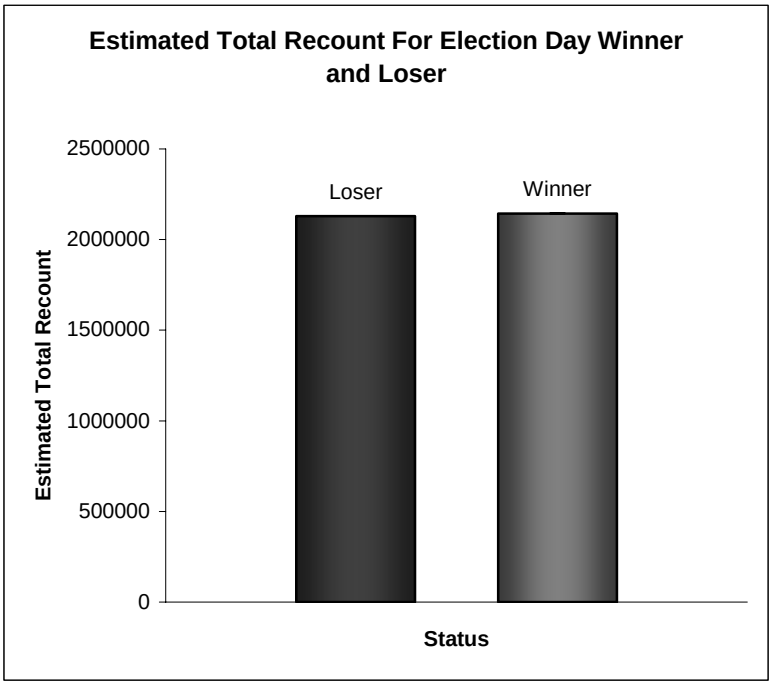
Probability That the Election Day Winner Defeated the Loser

Obs	MEAN	SEMEAN	WSUM	Atotal	SEAtotal
1	0.4736	0.4124	3197.0000	4737524.22	2025360.54
2	0.4736	0.4124	3197.0000	4737524.22	2025360.54
3	0.4736	0.4124	3197.0000	4737524.22	2025360.54

Obs	RatioA	SERatio A	Dzero	t	probt	DiffProb
1	4272810.31	681.876	2.217	4.23	0.99998	.000018985
2	4272810.31	681.876	1.953	3.59	0.99978	.000215924
3	4272810.31	681.876	550.123	1332.79	1.00000	0

Attachment C.2

Figure 1. Estimate of Actual Statewide Vote Count for Election Day Winner and Loser



Estimating ratio for Aw and Al

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Number of observations read : 275 Weighted count : 3197
Denominator degrees of freedom : 175

Date: 12-12-2008 Research Triangle Institute Page : 1
Time: 16:08:47 The RATIO Procedure Table : 1

Variance Estimation Method: Taylor Series (STRWOR)
by: Variable, One.

Variable		One 1
RECOUNTMC/MACHINEMC	Ratio Est.	1.000162
	SE Ratio	0.000064
	Weighted Y-Sum	2194155
	Weighted X-Sum	2193800
RECOUNTOBA/MACHINEOBA	Ratio Est.	1.000596
	SE Ratio	0.000213
	Weighted Y-Sum	2543370
	Weighted X-Sum	2541856

95% Confidence Interval for the Estimated Actual Total Recount of Election Day Winner and Loser

Obs	Status	RHAT	SERHAT	WYSUM	WXSUM
1	Loser	1.000162	0.000064	2194154.61	2193799.95
2	Winner	1.000596	0.000213	2543369.61	2541855.66

Obs	Vtotal	se ATotal	EstATotal	UCI95	LCI95
1	2128474	137.167	2128818.10	2129086.95	2128549.26
2	2142651	455.328	2143927.18	2144819.62	2143034.73